UNCLASSIFIED

AD NUMBER

AD473888

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution: DTIC users only.

AUTHORITY

DNA ltr., 28 Jan 80

THIS PAGE IS UNCLASSIFIED

DIRECTOR OF SHIP MATERIAL

BUREAU OF MEDICINE AND SURGERY RESEARCH GROUP

REPORT

EFFECTS OF AN ATOMIC BOMB EXPLOSION ON CORN SEEDS

APPENDIX NO. 9
TO THE FINAL REPORT

OPERATION CROSSROADS
JOINT TASK FORCE ONE

DIRECTOR OF SHIP MATERIAL

NAVAL MEDICAL RESEARCH SECTION

6

23 May 1947

OPERATION CROSSROADS.

EFFECTS OF AN ATOMIC BOMB EXPLOSION ON CORN SEEDS

Report of Naval Medical Research Section, Joint Task Force ONE, on Biological Aspects of Atomic Bomb Tests.

7 Appendix No. 9 To Final rpt.,

By

10 L. F. RANDOLPH

~~Department of Botany~~
[redacted]

11 23 May 47,

12 22p.

14 XRD-167

8

Approved:
R. H. DRAEGER
Captain, MC, U.S. Navy
Officer-in-Charge

1V3600

INTRODUCTION

The atomic bomb detonation at Bikini during Operation Crossroads offered the opportunity for exposing various biological materials including corn seed to ionizing radiation. This experiment with corn was designed to determine the effects of radiation from the atomic bomb in causing (1) alterations of the chromosome mechanism of heredity; (2) direct injurious action on the plants grown from the treated seed; and (3) sterility due to chromosomal derangement and other causes. For purposes of comparison duplicate samples of seed were exposed to measured dosages of X-rays ranging from 5,000 r to 25,000 r units.

EXPERIMENTAL PROCEDURE AND RESULTS

Sample plantings of 50 seeds of each of the numbered lots recovered at Bikini were made in the greenhouse at Beltsville on 19 July, immediately after they were received from the Pacific. Inspection of the seedlings on 29 Julyrevealed that the germinability of the seeds had not been affected and only one sample, No. 3, showed any noticeable radiation effects. The growth of these seedlings was somewhat retarded and their leaves had a mottled and streaked appearance comparable to similar effects induced by X-ray dosages of from 10,00 to 15,000 r units unfiltered radiation produced by a tungsten target tube operated at 80KVP (Figure 1).

Field plantings of Bikini lots 1,2,3,6 and 7 controls and samples of seeds X-rayed with 5,000; 10,000; 15,000; 20,000; and 25,000 r units were made on August 1 at Arcadia, California.

The extent of the mottled and streaked appearance of the seedlings in the No. 3 sample grown at Arcadia was similar to that noted at Beltsville.

The other Bikini samples were normal in the seedling stage, as they were at Beltsville, and there was no appreciable retardation in growth rate as the plants matured. Retardation of growth was noted in a small percentage of the plants of lot No. 3 and in the plants given 10,000 and 15,000 r-units of X-rays. Much more extensive injury to the plants was noted in the more heavily X-rayed lots given 20,000 and 25,000 r-units.

The individual mottled areas on the seedlings leaves were composed of groups of relatively small numbers of cells that presumably originated from a single cell initial at the time of irradiation. These affected areas were larger and more widely spaced in the older leaves and other organs of the plant.

As the plants approached morphological maturity three general categories of visible sectors were noted on the leaves and leaf sheaths of plants that showed mottling and streaking in the seedling stage. These were (1) chlorophyll deficiencies, (Figure 2,3) (2) morphological anomalies as twisted, crinkled, diminutive or otherwise deformed leaves (Figures 4-6), and (3) dead tissue which often resulted in a longitudinal slitting of the leaves (Figure 7). The observed frequencies of the various types of sectors are given in Table 1.

Table 1.

Plant Sectors of Chlorophyll Deficiencies, Morphological Abnormalities and Dead Tissue in X-rayed 15,000 r and Bikini No. 3 Samples..

	Chlorophyll Deficiencies	Morphological Abnormalities	Dead Tissue	Total Sectors	Plants Examined	Average No. Sectors Per Plant
15,000 r	68	22	20	110	249	0.44
No. 3	126	19	73	218	320	0.60

The data on visible plant sectors were taken from the leaves formed by the shoot apex after the seed germinated and did not include the first formed leaves whose initials are present in the embryo of the seed. The sectors that were recorded varied in length from approximately 5 cm. to the entire length of the leaf and leaf sheath and in width ordinarily from 2 to 15 mm. The width of the sectors very rarely exceeded one-quarter of the width of the leaf, the larger sectors being found most frequently in the larger leaves in the region of the functional ear shoot. The prevalence of numerous, relatively small sectors in the mature plant may have been due either to delayed action of the radiations or to the persistance in the region of the shoot apex of cell initials that were present in the seed. In the cytological studies of chromosomal aberrations and aborted pollen sectors were detected in the tassels which ordinarily affected less than one quarter of the tassel branches and main spike and these corresponded closely in size to those present in the leaves.

For the cytological analysis of chromosomal alterations induced by the atomic bomb microsporocyte samples were collected from the young tassels of approximately 350 plants of the No. 3 and 15,000 r cultures and much smaller numbers from the 10,000 r and 20,000 r samples. In collecting sporocyte samples from individual plants approximately one-third of the tassel branches were removed, leaving the main spike and the remainder of the tassel branches for pollen analysis and for outcrossing to untreated plants. The results of the pachytene, diakinesis, metaphase and anaphase analyses of the first meiotic division are summarized in Table 2.

Table 2.- Branches with normal and abnormal chromosomes having translocations, inversions and deletions observed at different stages of meiosis in X-rayed 15000 r and Bikini No. 3 sample.

	Diakinesis			Anaphase			Pachytene			Type of Abnormality		
	N.	Abn.	% Abn.	N.	Abn.	%Abn.	N.	Abn.	%Abn.	T	I	D
15,000 r	340	84	24.7	374	2	0.6	184	69	37.5	44	8	7
Bikini No. 3	721	100	13.8	387	3	0.8	437	98	22.4	61	15	13

A list of the individual plants that were examined and the number of tassel branches of each plant, the meiotic stages and the kinds of chromosomal derangements observed is appended to this report. The total number of plants examined was 191 from lot No. 3, and 93 from the cultures given 15,000 r-units of X-rays. Included among the total number of chromosomal alterations from both lots were 105 reciprocal trans-locations of which 80 were fully identified with respect to the chromosomes concerned and the approximate position of the break in each chromosome. There were also 23 inversions, 20 deletions and a small number of inversion-translocation complexes, most of which were fully analyzed with respect to their location in the chromosomes.

The observed frequency of chromosomal alterations per plant was 89/191 for the No. 3 sample and 59/93 for the X-rayed series. Since less than one-third of the tassel branches of each plant were examined in most cases, the No. 3 plants must have contained on the average at least 1.5 sectors per plant and the X-rayed plants at least 2 sectors per plant of cytologically distinct chromosomal alterations.

The same kinds of visible changes in the chromosomes were induced by the atomic bomb and by the X-ray treatments. As indicated in

Table 2 the percentage of abnormal branches was somewhat higher in the plants irradiated with 15,000 r-units of X-rays than in the plants of the No. 3 lot which were subjected to the radiations of the atomic bomb. These relative frequencies are in close agreement with those observed for visible plant sectors.

As noted in the appended list of plants examined, the tassel sectors in which the chromosomal alterations were detected usually involved from one to three tassel branches or roughly from one-sixteenth to one-quarter of the tassel. Thus the tassel sectors including chromosomal aberrations in general, were similar in extent to those affecting the visible appearance of the upper leaves in the plants of the same cultures.

A further comparison of the effects of the atomic bomb and X-radiations was obtained from an analysis of the frequency of aborted pollen in the main spike of the tassels. The number of plants examined in the various lots and the frequencies of sectors with abnormal pollen were as follows:

X-ray Series	Plants Examined	Plants with sectors of abnormal pollen	Per cent
5,000 r	176	52	29.5
10,000 r	170	90	52.9
15,000 r	532	335	63.0
20,000 r	135	95	70.4
Bikini Series			
Lot 1	407	72	17.7
2	399	59	14.6
3	831	524	63.1
6	402	29	7.2
7	397	16	4.0

These figures do not give the total number (percentage) of plants with sectors of partially sterile pollen, but only of plants where such sectors occurred within the limited portion of the central spike shedding the day collected. In order to get some sort of a picture of size and frequency of sectors, 124 whole tassels from Lot 3 were examined, taking a sample of pollen from each side branch as well as the central spike. A total of 1782 side branches were examined, of which 561½ or 31.5 per cent were abnormal. The size of sectors varied from a portion of one branch to nearly the whole tassel, but the small sectors were in greatest abundance. The frequencies are as follows:

Branches per sector	Number of sectors
½ to 1	46
1½ to 2	45
3	29
4	28
5	[illegible]
6	9
7	2
8	3
9	1
10	1
11	1
12	1
13	2
14	1

The mean size of observed sector is approximately 3 branches. The median is two and one half branches, i.e., one half of the sectors are 2.5 branches or less in size, and an equal number 2.5 branches or larger.

These sectors were distributed on the plants as follows:

All normal	10
One sector	59
Two sectors	45
Three sectors	7
Four sectors	2
Five sectors	1

The average number of observed sectors per plant was about 1.6.

The above figures are based on sectors which were recognized as distinct in type of pollen. Undoubtedly many sectors were lumped because the pollen type was not clearly distinct. When several sectors are present in one tassel, it is frequently impossible to recognize each one as distinct. This difficulty is reflected in the abrupt drop in frequency of plants with more than two observed sectors. Thus there is a systematic error running through all these figures except the total of 31.5 per cent of all branches visibly normal. This abnormal tissue must be distributed in a larger number of sectors of smaller size than observed. A reasonable estimate might well be an average frequency of between 2 and 3 abnormal sectors per plant and the median for size of sector at about 2 branches.

Assuming that the effect of the atomic radiations are immediate (not delayed to later cell generations) the above data indicate that on the average about seven or eight of the cells present in the shoot apex of dormant seed are represented in the reproductive cells of the tassel of the main stalk.

CONCLUSIONS

The observations on the effects of the radiations from the atomic bomb on corn plants indicate that with respect to retardation of growth, seedling mottling and the production of morphological abnormalities and partial sterility the No. 3 lot of corn seed located in the pilot house of the Independence was affected in much the same manner as comparable seeds exposed to from 10,000 to 15,000 r-units of X-radiation

from a tungsten tube operated at 80 K.V.P. Other lots of seed in the target area at Bikini were affected only slightly or not at all.

The direct cytological examination of the chromosomes of the No. 3 and 15,000 r samples revealed that the same kinds of chromosomal alterations including reciprocal translocations, inversions and deletions were produced by both types of radiations and in the same relative proportions.

The cytological observations on the chromosomes and pollen and the visual inspection of the seedlings and plants were in close agreement with respect to frequency of occurrence of abnormalities induced by the bomb and X-rays. The effects of the bomb on the No. 3 sample were slightly less than those induced by 15,000 r-units of X-radiation.

SUMMARY OF CYTOLOGICAL DATA FROM CORN TREATED WITH X-RAYS

Plant No.	Number of branches examined						Chromosomal aberration
	Diakinesis		Anaphase		Pachytene		
	Nor.	Ab.	Nor.	Ab.	Nor.	Ab.	
(10,000 r)							
4223- 4	3	0	0	0	0	0	
18	2	0	0	0	0	0	
49	5	0	0	0	0	0	
65	7	0	0	0	0	0	
(15,000 r)							
4225- 1	3	0	3	0	0	0	
2	6	0	6	0	0	0	
3	3	1	3	0	0	0	R4
5	0	0	1	0	0	0	
7	5	0	5	0	0	0	
8	6	0	6	0	0	0	
9	6	0	6	0	1	0	
11	6	0	6	0	0	0	
12	7	0	6	1	0	0	several bridges
13	5	0	5	0	0	0	
15	5	0	5	0	0	0	
16a	4	1	4	0	0	0	R4
16b	0	0	0	0	0	0	
18	2	2	2	0	0	0	C4 not 6
19a	4	0	4	0	0	0	

SUMMARY OF CYTOLOGICAL DATA FROM CORN TREATED WITH X-RAYS

Plant No.	Number of branches examined: Diakinesis Nor.	Diakinesis Ab.	Anaphase Nor.	Anaphase Ab.	Pachytene Nor.	Pachytene Ab.	Chromosomal aberration
4225- 19b	7	0	7	0	0	0	
20	5	0	5	0	0	0	
21	5	0	5	0	0	0	
23	8	0	8	0	0	0	
27	1	0	1	0	0	0	
28	1	1	2	0	0	0	C4
30	6	0	6	0	0	1	D5L.2-.3 ?
32	2	0	0	0	0	0	
33	6	0	6	0	0	0	
34	4	2	6	0	0	0	R4
36	1	1	0	0	0	0	C4
37	2	0	0	0	0	0	
38	0	4	4	0	0	2	T1L.8-3L.7
40	1	0	1	0	0	1	I9S.6-L.7 (2a)
41	6	0	5	0	1	0	
42	2	0	4	0	2	0	
43	5	0	5	0	0	0	
44	2	0	2	0	2	0	
45	3	1	4	0	4	0	R4
47	3	1	4	0	0	0	R4 not 6
48	5	0	5	0	5	0	
49	3	2	5	0	3	2	T6L.2-8L.1
50	2	1	0	0	0	0	R4
51	6	3	5	0	4	2	T6L.8-8L.9 (1b)
53	6	1	4	0	5	1	D10S.5-S.7 (2d);D7L.1-L.5 inserted at L.5 of the homologue in inverted order (2g) T2L.7-4L.2
54	5	0	3	0	2	0	
56	1	1	2	0	0	0	
57	4	1	5	0	4	1	T5L.7-10L.6; D1S.05-S.15
58	5	1	6	0	5	1	T3-5 ? ; I1S.4-.9
61	0	0	0	0	0	0	
62	6	0	3	1	3	4	I7L.1-L.6 (2b)
64	3	4	7	0	3	4	T4 L.3-7L.1; T3L.4-10L.2
67	1	0	1	0	1	0	
68	3	0	3	0	1	2	D8L.5-L.65 (2e)
76	0	5	2	0	0	5	T2L.3-7L.2 (1c) T3S.5-4S.7 (1d)
77	5	0	4	0	5	0	
78	4	3	7	0	4	3	T3S.95-6L.6 (2 branches) T3S.9-4S.5; 6L.1-8L.2
79	0	3	3	0	0	3	T2L.4-6L.7

Plant No.	Number of branches examined: Diakinesis Nor.	Diakinesis Ab.	Anaphase Nor.	Anaphase Ab.	Pachytene Nor.	Pachytene Ab.	Chromosomal aberration
4226-1	3	4	7	0	3	4	T1S.2-7L.6
3	8	0	8	0	8	0	
4	0	0	0	0	0	0	
5	7	1	8	0	7	1	T1L.7-2 or 3L.6 ?
6	4	0	4	0	4	0	
9	3	0	3	0	3	0	
10	3	3	6	0	3	3	T6L.9-9L.1
12	3	3	6	0	0	0	R6 ≠ R4 (2 branches); C4
19	4	1	5	0	4	1	I5S.4-L.5
20	4	1	5	0	4	1	T8S-10S ?
24	6	0	6	0	6	0	
26	6	0	6	0	5	1	D5?8?9
27	5	0	5	0	5	0	
28	3	2	5	0	3	2	T2 or 4S.3-5S.3
34	2	0	0	0	2	0	
35	3	2	5	0	3	2	T1L.2-3S.5
38	3	4	7	0	3	4	T1L.7-4L.8
39	4	1	5	0	4	1	T1L.95-4L.9 sliding
40	0	3	3	0	0	3	T1L.2-10L.7
42	5	0	4	0	5	0	
43	5	0	5	0	5	0	
47	3	3	6	0	0	0	
48	5	0	5	0	5	0	R4
49	4	0	4	0	0	1	I4L.1-L.4; I6L.6-L.8
53	5	1	6	0	5	1	T6L-10L. ?
57	6	0	6	0	6	0	
66	0	2	2	0	0	2	T5L.2-6L.2
68	8	0	8	0	4	0	
74	4	1	5	0	4	1	TsL.6-4L.3
78	1	5	6	0	1	5	TsL.05-7L.1-10L.5?
83	7	0	7	0	7	0	
86	2	0	2	0	2	0	
87	2	3	5	0	2	1	T2-3
88	0	1	1	0			Ç4(6)
89	4						
92	1	3	1	0	1	3	D8L.5-L.65(2f) I3L.05-L.3 (2c) T2S.75-6L.7 (1b) T5L.3-10L.5 (1e)
4236-69	7	0	0	0	0	0	
93	1	0	0	0	0	0	
4238-24	2	0	1	0	3	0	
37	6	1	7	0	5	1	T1S.3-5L.1 (1a)

Plant No.	Number of branches examined: Diakinesis Nor.	Diakinesis Ab.	Anaphase Nor.	Anaphase Ab.	Pachytene Nor.	Pachytene Ab.	Chromosomal aberration
(20,000 r)							
4227-51	4	2	0	0	0	0	R4 + C4 not 6
4228- 8	0	2	0	0	0	2	T?-6L.5; R4+C4 I+Din C4
31	3	0	0	0	0	0	

BIKINI SAMPLE NO. 3

Plant No.	Diakinesis Nor.	Diakinesis Ab.	Anaphase Nor.	Anaphase Ab.	Pachytene Nor.	Pachytene Ab.	Chromosomal aberration
4229- 1	3	1	0	0	0	0	R6
3	3	0	2	0	0	0	
4	3	2	2	0	0	0	C4
6	2	0	0	0	0	0	
7	6	0	0	0	0	0	
8	7	0	1	0	0	0	
10	4	0	0	0	0	0	
12	1	0	0	0	0	0	
14	4	0	0	0	0	0	
16	6	0	0	0	0	0	
18	7	0	2	0	0	0	
20	5	0	0	0	0	0	
21	5	1	0	0	0	1	I8L.6-L.9 (10a) T5L.9-10S.9 (7a)
23	2	0	0	0	0	0	
24	5	0	1	0	0	0	
28	2	2	0	0	0	0	
29	5	0	0	0	0	0	
30	5	0	0	0	0	0	
31	6	0	0	0	0	0	
36	4	0	0	0	0	0	
37	7	0	0	0	0	0	
38	6	0	0	0	0	0	
39	7	0	0	0	0	0	
43	2	0	0	0	0	0	
44	4	0	0	0	0	0	
48	2	0	0	0	0	0	
49	2	0	2	0	1	0	
51	5	0	5	0	4	1	T6L.8-8L.9
60	5	0	2	0	7	0	
64	2	0	0	0	0	0	
65	4	0	0	0	0	0	
66(76)	1	1	1	0	0	0	R4
68	3	0	0	0	0	0	
69	7	1	0	0	0	0	R4
76(66)	1	0	0	0	0	0	
77	8	0	0	0	0	0	

Plant No.	Number of branches examined						Chromosomal aberration
	Diakinesis		Anaphase		Pachytene		
	Nor.	Ab.	Nor.	Ab.	Nor.	Ab.	
(20,000 r)							
4229-79	2	0	0	0	0	0	
80	1	0	0	1	0	1	I4L.4-L.6
82	7	0	0	0	0	0	
83	6	0	0	0	0	0	
84	5	0	0	0	0	0	
85	6	0	0	0	0	0	
87	2	1	0	0	0	0	R4
90	5	0	0	0	0	0	
92	1	1	0	0	0	0	R4
93	3	0	0	0	0	0	
94	3	0	0	0	0	0	
97	3	0	0	0	0	0	
98	5	0	0	0	0	0	
99	3	0	0	0	0	0	
103	6	0	0	0	0	0	
106	4	1	0	1	0	0	R4 8-I
107	5	2	0	0	0	0	R4
112	2	0	0	0	0	0	
122	6	2	2	0	0	2	T5L.9-8L.4 (7b)
124	5	1	4	0	0	1	T5L.05-10L.3 (7c)
126	2	0	0	0	0	0	
129	0	1	0	0	0	0	T7S.8-8L.85 (6e)
130	3	1	0	0	0	1	T1L.9-3L.95 (3h)
131	4	0	4	0	4	0	T6-5 ?
132	[illegible]	0	2	0	0	0	
134	2	0	0	0	0	0	
135	8	0	1	0	0	0	
136	4	3	1	0	0	2	T1L.6-3L.8 (3c)
139	5	1	6	0	2	1	D7L.05-.15
140	1	0	0	0	0	0	
142	3	0	0	0	0	0	
144	3	0	3	0	3	0	
152	5	1	4	0	4	1	T3S.2-8L.5 (5d)
152(a)	4	0	3	0	4	0	
155	3	1	2	0	0	0	R6
159	3	0	3	0	3	0	
160	4	0	2	0	0	0	
4230- 1	2	0	2	0	2	0	
3	1	0	0	0	2	1	I5S.03-L.4 (9a)
5	2	2	1	0	0	2	T1L.3-5L.5 (3e)
12	5	0	2	0	6	0	
13	1	0	0	0	0	0	
17	5	0	0	0	0	0	
21	4	0	2	0	5	0	

Plant No.	Numbers of branches examined: Diakinesis Nor.	Diakinesis Ab.	Anaphase Nor.	Anaphase Ab.	Pachytene Nor.	Pachytene Ab.	Chromosomal aberration
(20,000 r)							
4230- 22	1	2	0	0	0	1	T1L.3-8L.4
25	2	0	1	0	3	1	I10L.1-L.5 (10h)
26	5	0	3	0	3	0	
27	5	0	5	0	3	0	
34	1	0	0	0	0	0	
36	3	3	6	0	2	2	T1L-5S ?
39	0	1	0	0	0	0	R4 sector
40	1	0	1	0	1	0	
41	8	1	9	0	8	1	T2S.8-8S.6
42	4	3	7	0	4	3	I6S.95-L.2
43	7	0	7	0	7	0	
44	4	2	6	0	4	2	T2L.3-8L.8 (5b)
46	6	0	6	0	5	0	
47	2	0	1	0	2	0	?
48	2	1	3	0	2	1	T1L.7-3L.?
49	1	0	1	0	1	0	
50	6	1	7	0	6	1	T2S.2-3S.3?
51	1	0	0	0	0	0	
52	2	0	0	1	0	3	I4L.4-L.55 (8e) D6L.8-L.9 (9d)
53	4	0	4	0	4	0	
54	4	0	2	0	3	0	
58	5	0	5	0	6	0	
64	4	1	4	0	3	2	D2L.7-85 (8d) T1-8
65	4	0	4	0	5	0	
66	1	0	1	0	0	0	
68	4	4	8	0	4	0	T4S.8-7S.4 (6a)
69	9	0	7	0	9	0	
71	5	1	3	0	5	2	I1L.05-L.25 (8a) D9S.6-S.8 (10f) T4S.2-10L.05 (6d)
73	5	1	1	0	5	1	T1L.2-9S.8 (4d)
76	0	0	0	0	3	1	I8L.5-L.85 (10c)
77	2	0	0	0	6	0	
79	5	0	1	0	7	0	
80	5	1	4	0	3	1	T1L.4-6L.3 (4f)
81	5	1	4	0	5	1	T2L.35-8S.1 (5c)
83	3	2	3	0	5	2	T4L.2-7S.2 (6b)
84	4	2	4	0	4	1	T1S.7-9S.8 (4e)
85	5	0	2	0	6	0	
89	3	1	0	0	4	1	T2L.05-5S.1 (5a)
92	7	0	6	0	7	0	
93	3	1	0	0	4	1	D5L.85-L.95 (9c)

Plant No.	Number of branches examined: Diakinesis Nor.	Diakinesis Ab.	Anaphase Nor.	Anaphase Ab.	Pachytene Nor.	Pachytene Ab.	Chromosomal aberration
(20,000 r)							
4230- 94	5	0	4	0	5	0	
95	3	0	2	0	4	1	D7L.4-L.6 (9[illegible])
98	6	0	5	0	4	2	I1S.06-L.05 (8b)
100	9	1	3	0	4	3	I5S.7-L.35 (9b) T1S.25-8S.9 (4b)
102	2	0	2	0	0	0	
103	6	0	4	0	5	1	D8L.1-L.6 inserted at L.6 of the homologue in inverted order (10e)
104	0	0	0	0	1	0	
106	2	3	1	0	3	4	T1S.3-6L.25 (3f)
107	5	0	3	0	4	1	I7S.4-L.55 (9h)
108	4	3	2	0	4	3	T1L.15-6L.25 (3g)
110	5	0	0	0	7	0	
112	0	6	0	0	0	2	R4 Pa. made but not studied
114	4	0	1	0	4	0	
115	5	0	4	0	3	2	I1S.3-L.3 (8c)
117	3	0	1	0	5	0	
118	4	3	1	0	4	3	T1L.1-2S.05 (3a)
119	3	0	1	0	0	0	
120	6	0	2	0	0	0	
121	5	0	2	0	6	0	
124	7	0	3	0	4	2	D4L.1-L.2 (8b) I8L.3L.55 (10b)
125	2	0	5	0	2	1	T6S.8-8S.5 (7f)
126	6	1	1	0	8	1	T1S.65-7L.4 (4a)
128	7	0	1	0	6	0	
129	0	3	1	0	0	4	T1L.15-8L.1 (4c)
131	4	1	1	0	4	1	T6-5 ?
132	5	0	3	0	0	0	
136	3	2	4	0	0	4	T5S.3-8S.6 (7e) D8L.05-L.9 (10d)
137	6	0	3	0	0	0	
138	7	0	1	0	7	0	
139	3	0	1	0	4	0	
140	5	1	3	0	0	1	T3L.05-8L.7 (5e)
142	6	0	2	0	5	1	D9L.3-L.7 (10g) D6L.01-L1.0 (9e)
144	0	2	1	0	0	0	R4 6-?; R4 ?-? not 6
145	9	0	2	0	7	1	D6S.2-S.8 (9f)
147	1	0	2	0	3	0	
150	4	0	2	0	0	0	
151	2	3	2	0	0	3	T5S.3-7S.2 (7d)

Plant No.	Number of branches examined						Chromosomal aberration
	Diakinesis		Anaphase		Pachytene		
	Nor.	Ab.	Nor.	Ab.	Nor.	Ab.	
(20,000 r)							
4230 -153	4	1	0	0	4	2	I4S.1-S.3 (8g) T4L.3-8L.15 (6c)
155	6	1	3	0	6	1	T1L.1-3L.03 (3d)
156	3	0	3	0	3	0	non pairing near knob of 5
157	0	0	0	0	0	0	
160	2	2	0	0	2	2	Trisomic 7
4231- 1	8	0	8	0	8	0	
4	4	0	3	0	5	0	
6	6	0	6	0	6	0	
7	4	2	6	0	4	2	T1L.5-10S.5
8	3	2	1	0	3	2	T2S.?Centrome-7S.3 T6L.3-?
10	5	0	5	0	5	0	
13	5	0	5	0	0	0	
14	1	0	1	0	1	0	
16	1	2	3	0	1	2	T1S.4-7L.6; T4S.2-5L.6
17	3	0	3	0	3	0	
34	2	0	2	0	2	0	
40	7	0	7	0	0	0	
47	6	0	6	0	6	0	
48	2	0	2	0	5	0	
49	6	0	6	0	6	0	
50	6	0	3	0	6	0	
51	7	0	0	0	0	0	
52	1	2	3	0	1	2	T1S.95-3S.5
55	7	0	7	0	7	0	
57	2	0	2	0	2	0	
61	0	0	0	0	0	0	
63	3	2	5	0	3	2	T2S.6-6S.95(sat.);T4L.8-8L.1
66	5	0	4	0	5	0	
67	2	0	2	0	2	0	
68	7	1	8	0	7	2	T1S.3-10L.2;D8S.9-S1.0
70	9	0	9	0	9	0	
73	7	0	7	0	0	0	
79	5	1	6	0	5	0	C4

Figure 1. Streaking of seedling leaves observed in Bikini Lot No. 3.

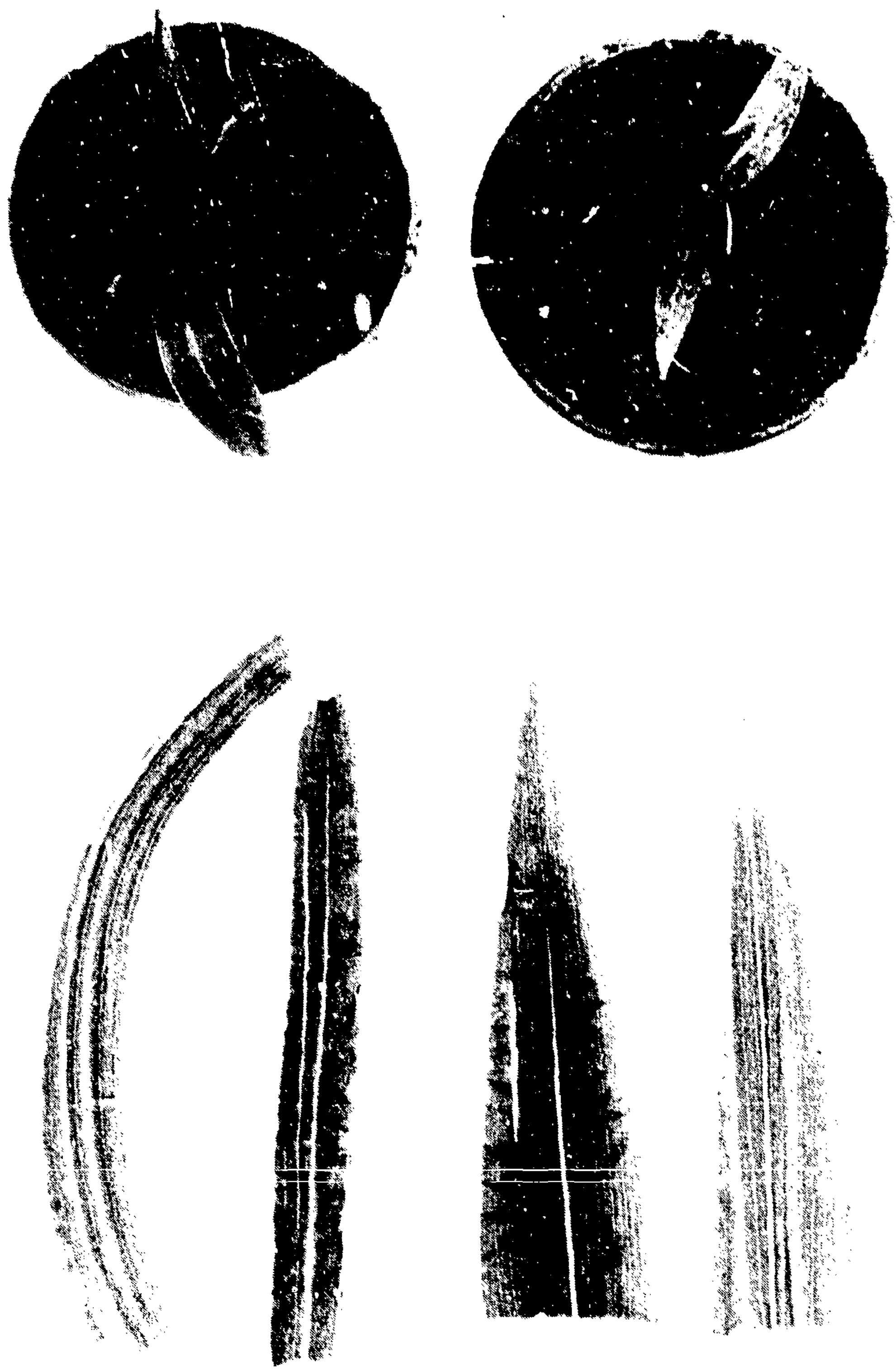

Figure 2. a. Seedlings untreated (left) and from X-rayed with 15,000 r-units.

b. Sectors of chlorotic tissue and asymmetric growth in irradiated leaves.

Figure 3. Chlorophyll deficient sector.

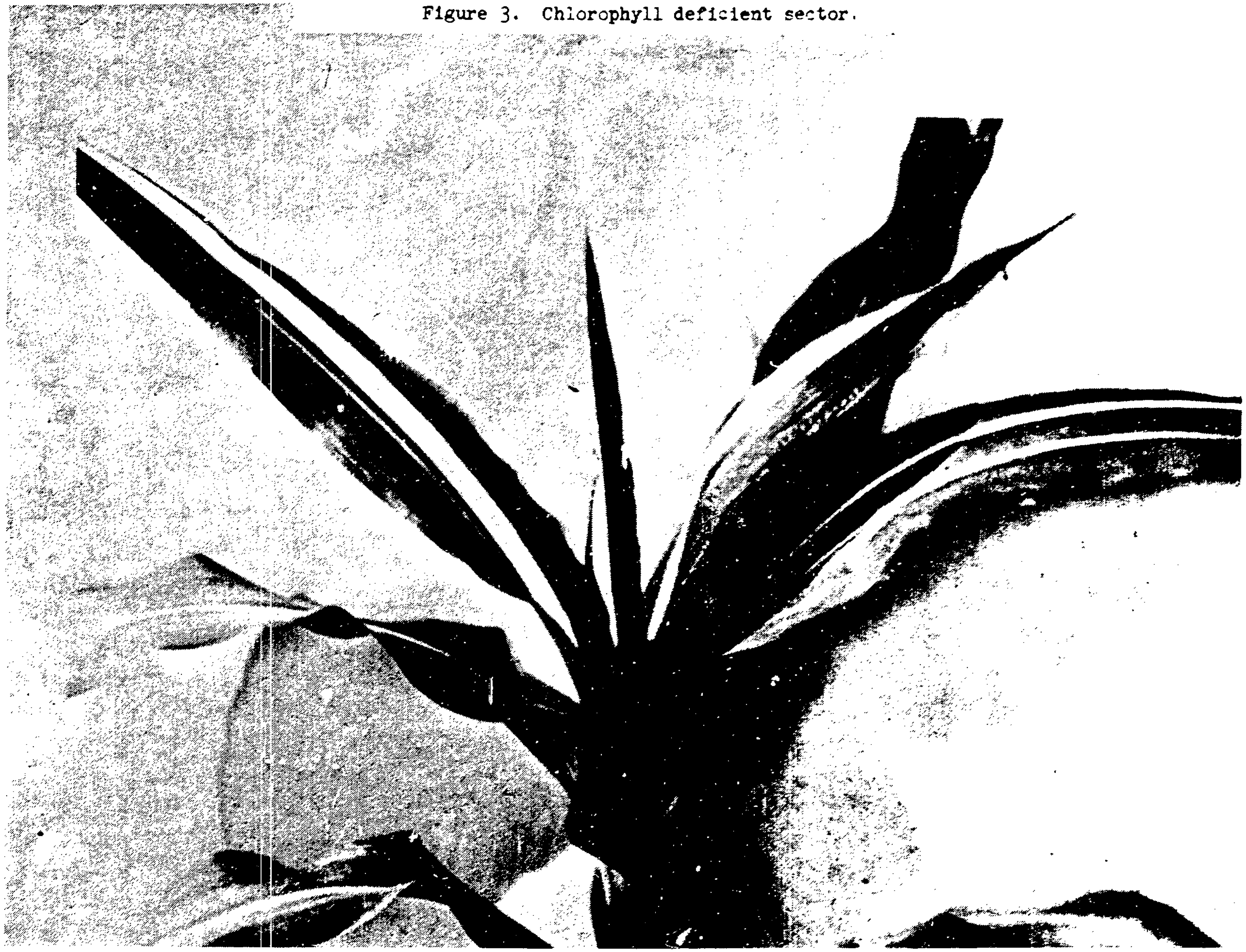

Figure 4 Twisted leaf due to sector deficient in growth rate on one side of the leaf.

Figure 5. Diminuitive leaves lacking ligule and typical sheath.

Figure 6. Diminuitive leaves lacking ligule and typical sheath.

Figure 7. Slit leaf blades due to sectors of dead tissue.

51 38780

Defense Special Weapons Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

TRC

10 April 1997

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTENTION: OMI/Mr. William Bush

SUBJECT: Declassification of Reports

The Defense Special Weapons Agency (formerly Defense Nuclear Agency) Security Office has reviewed and declassified the following reports:

AD-366718	XRD-32-Volume 3	
AD-366726	XRD-12-Volume 2	
AD-366703	XRD-16-Volume 1	
AD-366702	XRD-14-Volume 2	
AD-376819L	XRD-17-Volume 2	
AD-366704	XRD-18	
AD-367451	XRD-19-Volume 1	
AD-366705	XRD-20-Volume 2	AD-366705
AD-376028L	XRD-4	
AD-366694	XRD-1	
AD-473912	XRD-193	
AD-473891	XRD-171	
AD-473899	XRD-163	
AD-473887	XRD-166	
AD-473888	XRD-167	ST-A 28 JAN 80 made target
AD-473889	XRD-168	

TRC 10 April 1997

SUBJECT: Declassification of Reports

AD-B197749	XRD-174
AD-473905	XRD-182
AD-366719	XRD-33 Volume 4
AD-366700	XRD-10
AD-366712	XRD-25 Volume 1
AD-376827L	XRD-75
AD-366756	XRD-73
AD-366757	XRD-74
AD-366755	XRD-72
AD-366754	XRD-71
AD-366710	XRD-23 Volume 1
AD-366711	XRD-24 Volume 2
AD-366753	XRD-70
AD-366749	XRD-66
AD-366701	XRD-11
AD-366745	XRD-62.

All of the cited reports are now **approved for public release; distribution statement "A" applies.**

Ardith Jarrett
ARDITH JARRETT
Chief, Technical Resource Center

copy furn: FC/DSWA (DASIAC)
KSC

Completed

B.W